AIR FORCE

QUALIFICATION TRAINING PACKAGE (AFQTP)

for

HVAC/REFRIGERATION

(3E1X1)

MODULE 13

WELDING & CUTTING

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MODULE 13

WELDING & CUTTING

Career Field Education and Training Plan (CFETP) references from 1 Apr 97 version.

OPR: HQ AFCESA/CEOF
AFCESA/CEO
(SMSgt Mike Shakal)

Certified by: HQ
(Colonel Lance C. Brendel)

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INTRODUCTION

Before starting this AFQTP, refer to and read the "Trainee/Trainer Guide" located on the AFCESA Web site **http://www.afcesa.af.mil/**

AFQTPs are mandatory and must be completed to fulfill task knowledge requirements on core and diamond tasks for upgrade training. ***It is important for the trainer and trainee to understand*** that an AFQTP ***does not*** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks.

MANDATORY minimum upgrade requirements:

Core task:
AFQTP completion
Hands-on certification

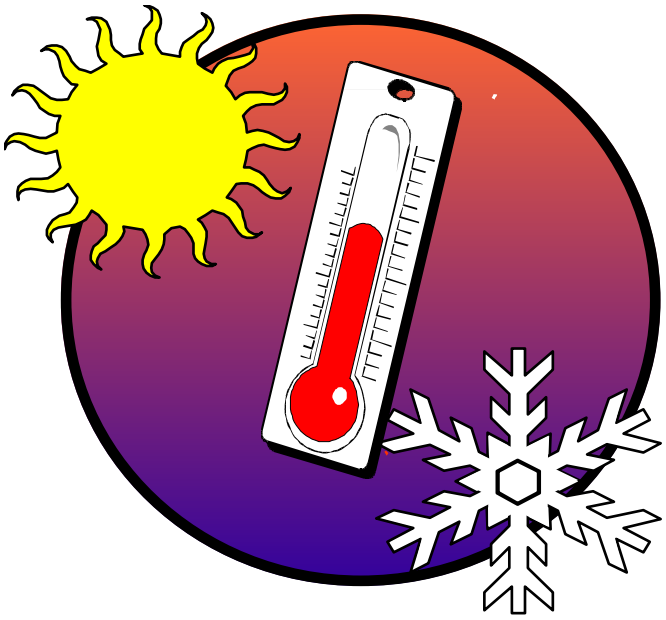
Diamond task:
AFQTP completion
CerTest completion (80% minimum to pass)

Note: *Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location*.

Put this package to use. Subject matter experts, under the direction and guidance of HQ AFCESA/CEOF, revised this AFQTP. If you have any recommendations for improving this document, please contact the HVAC/R Career Field Manager at the address below.

HQ AFCESA/CEOF
139 Barnes Dr. Suite 1
Tyndall AFB, FL 32403-5319
DSN: 523-6421, Comm: (850) 283-6421
Fax: DSN 523-6488
E-mail: ceof.helpdesk@tyndall.af.mil

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.



WELD AND CUT

MODULE 13 AFQTP UNIT 2

BRAZE AND SOLDER (13.2.2.)

BRAZE AND SOLDER

Task Training Guide

STS Reference Number/Title:	13.2.2. Braze and Solder
Training References:	• TR: TO's 32-1-101, 32-1-151, 34W4-1-7, 42D-1-3, 34W4-1-8; AFOSH 127-5
Prerequisites:	• Possess as a minimum a 3E131 AFSC.
Equipment/Tools Required:	• Oxyacetylene Equipment • Personnel Protective Equipment • Standard HVAC/R Tool Bag
Learning Objective:	• The trainee will know the steps to safely Braze & Solder
Samples of Behavior:	• Trainee will be able to Braze & Solder
Notes:	
• Any safety violation is an automatic failure	

BRAZE AND SOLDER

Background: Oxyacetylene welding includes several processes in which metal parts are joined together. In this unit, we will discuss several of these methods. However, before we can discuss the various oxyacetylene operations, you should acquaint yourself with the equipment you are required to use and its operation.

In this section we will cover assembling the equipment, operating the equipment, closing down the equipment, disassembling the equipment, testing the equipment for leaks, and troubleshooting equipment malfunctions. We will also cover the principles of oxyacetylene equipment.

Oxyacetylene Equipment. In order to use oxyacetylene equipment, you need to know something about it--the parts that make up the equipment, how it is assembled, plus the procedures for taking care of it. All of these items are covered in this section.

Characteristics of oxygen and acetylene and their containers are:

Oxygen. Oxygen is a colorless, tasteless, and odorless gas that is slightly heavier than air. It will not burn, but it does support combustion very actively, more so than air. This characteristic of oxygen makes it desirable to use with acetylene for welding, brazing, and silver soldering.

The oxygen cylinder is made of seamless steel and contains oxygen at a pressure of up to 2,000 pounds per square inch (psi). The container is green and equipped with a safety cap to protect the valve. The valve has a bursting disc for releasing pressure increases due to heat. It comes with right-hand threads to keep from confusing it with the acetylene connections. The great amount of pressure in an oxygen cylinder makes it a potential missile if the valve is broken off or the tank is pierced.

Acetylene. Acetylene is the fuel gas of the oxyacetylene flame. It is made by dissolving calcium carbide in water. Calcium carbide is made by fusing limestone and coke in an electric furnace. Acetylene is not an ordinary gas. It has characteristics peculiar to itself. It contains about 93 percent carbon and about 7 percent hydrogen. When burned in the presence of pure oxygen, it burns at a temperature of 6,300°F. Acetylene not only develops a large amount of heat, but also releases the heat units so rapidly that the highest temperature of the flame is produced almost instantly. *At pressures greater than 15 psi, acetylene is unstable and may split up or disassociate*. When pressure causes the gas to split up or decompose, this disturbance of the molecules releases heat until an explosion of the gas is produced. Above pressures of 29.4 psi, acetylene becomes self-explosive and a slight shock will cause it to explode spontaneously. However, when it is dissolved in acetone, it can be compressed into cylinders at pressures up to 250 psi. Mixtures of acetylene and air containing from 2 to 80 percent of acetylene by volume will explode when ignited. It requires 2½ parts of oxygen to consume completely 1 part of acetylene. It is not necessary however, to supply all this oxygen through the torch, because a portion of the oxygen is derived from the air surrounding the flame. The torch is designed to supply one part of oxygen to each part of acetylene that passes through it.

The acetylene cylinder is designed to store acetylene under pressure up to 250 pounds per square inch. The cylinder is made of welded or brazed steel and is filled with a substance that has a porosity of 75 to 80 percent. This substance is then filled with acetone to 40 percent of its liquid volume. This allows space for expansion as the acetone absorbs the acetylene to stabilize it under pressure.

The cylinder is equipped with a cylinder valve and a protective cap. As a safety factor, the valve has left-hand threads to prevent an improper connection. Another safety factor is the safety plugs for releasing the gas if the cylinder is overheated. These plugs melt between 212°F and 220°F and are small enough to keep the gas from burning back into the cylinder. All acetylene cylinders are yellow and must be stored upright to prevent the escape of the acetone.

Both oxygen and acetylene cylinders should be stored according to Air Force regulations. Here are a few rules to follow when storing cylinders:

- Keep oxygen cylinders away from oil and grease. Oil or grease mixed under pressure with oxygen may explode.
- Do not drop cylinders or handle them roughly.
- Store cylinders in a cool, dry, well-ventilated building.
- Store oxygen and acetylene cylinders in an upright, secured position. Separate full and empty cylinders.
- When a cylinder is empty, replace the safety cap and write "MT" on the cylinder in chalk.

The Parts of the Oxyacetylene Outfit. It takes many individual items to make up an oxyacetylene outfit. One of them is the cylinder that was covered in the previous section. Other items include:

Regulators. The regulators, or reducing valves, are mechanical devices that reduce the high pressure of the gases as they flow from the cylinders. Single-stage regulators reduce the high pressure of the gases as they flow from the cylinders to the working pressure needed at the torch in one step (stage). The two-stage regulators do it in two steps.

Hoses. Hoses take the gases at working pressure from the regulators to the torch needle valves. *The oxygen hose is always green or black, and the acetylene hose is always red or maroon.*

Torch. The gases flow from the hoses, through the open needle valves, through their respective tubes, and to the mixing head. The gases combine in the mixing head and flow forward through the tip to produce a flame.

Torch Tip. The torch tip directs the flow of the oxyacetylene mixture so that the flame can be controlled.

Torch Wrenches. Special torch wrenches are designed for use with an oxyacetylene outfit. A torch wrench has slots or holes the correct size to tighten all connections.

SAFETY.
THE WELDING GOGGLES, FLINT LIGHTER, AND FIRE EXTINGUISHER ARE ALL SAFETY EQUIPMENT USED WITH THE OXYACETYLENE OUTFIT. THIS EQUIPMENT IS DESIGNED TO PROTECT THE OPERATOR FROM INJURY AND TO PREVENT DAMAGE TO PROPERTY.

Assembling Oxyacetylene Equipment. To assemble portable equipment, place the acetylene and oxygen cylinders on the cart, secure them, and remove the cylinder valve protective caps. Open (crack) each cylinder valve slightly for an instant to blow out any dirt lodged in the outlet nipple.

Regulators. Attach the two regulators to their respective cylinders and tighten the union nut with the torch wrench.

Hoses. Attach the red acetylene hose to the acetylene regulator outlet (left-hand threads). Attach the green oxygen hose to the oxygen regulator outlet (right-hand threads). Screw the nuts tightly with the torch wrench. To make sure the regulator adjusting screws are backed out, turn them counterclockwise until they are loose.

Blowing out the hoses. Never open cylinder valves before releasing the regulator adjusting screws. Open the acetylene cylinder valve slowly one-fourth to one-half turn. Do *not* open the acetylene valve more than one-half turn. Next, open the oxygen valve slowly at first, then fully open. Read the high pressure gauges to check the pressure of each cylinder. Open each regulator by turning the adjusting screw clockwise. Blow out the hoses one at a time.

Connecting hoses to flashback arrestor. After blowing out the hoses, release the adjusting screws. Between the hoses and the torch install flashback arrestors. These are normally installed on the oxygen and acetylene torch gland nuts. They keep a flashback from burning back into the oxygen or acetylene hoses. After installing the flashback arrestors, connect the hoses to them. The red hose connects to the acetylene flashback arrestor with the left-hand threads, and the green hose connects to the oxygen flashback arrestor with the right-hand threads.

Torch Tip. Select the torch tip and attach it to the torch. Tighten the tip moderately. Now the outfit is totally assembled and ready for operation.

How to Light the Torch and Adjust its Flame:

Recommended working pressures. Before you can use an oxyacetylene torch, you must adjust the regulators for the right working pressure of the gases. To do this, first open the torch acetylene valve, adjust the regulator for the required pressure, and then close the torch acetylene valve. Adjust the oxygen working pressure in the same way. Now you are ready to light the torch.

Lighting the torch. To light the welding torch, first open only the acetylene torch valve. Strike the flint lighter in front of the tip, keeping your hand at one side. Push the arm of the lighter with the flint across the rough surface to make a spark. This lights the flame. Hold the torch so the flame is directed *away from* the cylinders, the hose, any flammable material, and yourself. The pure acetylene flame is long and bushy and has a yellowish color. Since the oxygen valve is closed at this point, the acetylene burns in combination with the oxygen in the air. Because there is not enough oxygen in the air to burn the acetylene completely, the flame is smoky. It produces a soot of fine, unburned carbon. **The pure acetylene flame is unsuitable for welding**.

When you open the oxygen valve, the flame shortens and the mixed gases burn in contact with the tip face. The flame changes to a bluish-white and forms a bright inner cone surrounded by an outer envelope. The inner cone develops the high temperature needed for welding. The outer envelope contains varying amounts of incandescent carbon soot, depending on the proportion of oxygen to acetylene. To adjust the torch for a neutral flame, open the torch oxygen valve slowly until the feather at the end of the central cone disappears. Three distinctive flames can be obtained with the oxyacetylene welding outfit: **neutral, reducing or carburizing, and oxidizing**.

Neutral Flame. There are two clearly defined cones in a neutral flame. The inner cone is luminous and bluish white. Around this cone is a colorless area surrounded by a large flame envelope or sheath, which is faintly luminous and has a light bluish tint. *The neutral flame is produced by a mixture of approximately one part of oxygen and one part of acetylene supplied from the torch.* **The temperature at the tip of the inner cone is approximately 5,850°F.**

Reducing or Carburizing Flame. *The reducing or carburizing flame is produced by slightly more than one part acetylene to one part oxygen.* To get this flame, adjust the welding flame to neutral and then open the acetylene torch valve slightly to produce a white streamer or "feather" of acetylene at the end of the inner cone. You can recognize the reducing or carburizing flame by the presence of three distinct flame cones: the clearly defined, intense, white, central cone; a white feather or intermediate reducing cone indicating the amount of excess acetylene; the light orange to bluish outer flame envelope. **The flame has a temperature of approximately 5,700°F at the tip of the central cone.**

Oxidizing Flame. *The oxidizing flame is produced by slightly more than one part of oxygen mixed with one part volume of acetylene.* To get this type of flame, adjust the torch first to give a neutral flame. Then increase the flow of oxygen by opening the oxygen torch valve. You can know this flame by the short, pointed central cone; a white or colorless middle cone; and a somewhat shorter outer flame envelope. There is a distinctive hissing sound. **This flame has a temperature of approximately 6,300°F.**

Here are the ways to shutdown the welding equipment:

Normal Shutdown. When you are closing down an oxyacetylene torch, close the torch oxygen valve first and then the torch acetylene valve. Close both cylinder valves. Open the torch valves one at a time (acetylene first) and bleed the regulators. Close the torch valves. Turn the regulator-adjusting screws counterclockwise to relieve the pressure of the diaphragm. Hang the torch and hose up properly to prevent kinking the hose or damaging the torch. Be careful not to damage the tip by letting it hit the cylinder or cart.

Emergency Shutdown. Used to close down in case of an emergency. **ALWAYS** shut off the acetylene torch valve **FIRST**, then the acetylene cylinder valve. The emergency shutdown of equipment may be necessary because of a flashback or other reasons. A flashback is the burning of gas inside the torch and is indicated by a high-pitched whistle. It can burn all the way back to the cylinder if it is not stopped. Flashback arrestors are installed between the torch and hoses to keep flashbacks from getting from the torch to the hoses. However, flashback arrestors are not foolproof--you should still shut down the equipment if a flashback occurs. If the flashback reaches the cylinder, the cylinder may explode. It is always dangerous; and the farther back it burns, the more the equipment is damaged.

Do not confuse a flashback with a backfire. A backfire is merely the popping of the torch caused by a dirty tip, a tip size that is too small, the tip held too close to the work, or too much gas pressure.

Disassembling oxyacetylene equipment. When it is necessary to disassemble a welding outfit, use a procedure that is the exact opposite of assembly.

To perform this task, follow these steps:

Step 1: Be sure the gas supply is off.

Step 2: Bleed the regulators.

Step 3: Remove the torch tip.

Step 4: Disconnect the hoses from the torch.

Step 5: Disconnect the hoses from the regulators.

Step 6: Disconnect the regulator from the cylinder or manifold line.

Step7: Replace the cylinder valve safety cap or line protective nuts.

> **NOTE:**
> When you are disassembling an outfit, use the torch wrench to prevent rounding the corners on the connecting nuts. Also, handle the tips, torches, and regulators carefully to prevent damage.

How to test for and stop welding equipment gas leaks. Before any oxyacetylene outfit is put into use, it should be thoroughly checked for gas leaks. The testing of the outfit is a very simple but important task. You can do it with a can or jar of soapy water, a small paintbrush or acid brush, and a bucket of clear water.

Checkpoints for leaks. After the outfit has been assembled and adjusted to a working pressure, test all the connections by brushing soapy water onto them. A leak is indicated by bubbles. Test all the hoses by submerging them in a bucket of clear water.

Leaking Regulators. The primary problem with regulators is gas leakage between the regulator seat and the nozzle. It can be detected by observing a gradual pressure rise on the working pressure gauge after the cylinder or manifold valve is opened. This is known as a "creeping regulator" and is caused by worn or cracked seats or by dirt particles lodged between the seat and the nozzle. A leaking regulator should be replaced by a good one, and the faulty one should be sent out for repair.

Gauges. Problems with a gauge are usually caused by a leaking or broken bourdon tube, indicated by fluctuating gauge pressure or gas leaking from the gauge case. The bourdon tube is a steel tube attached to the needle through a linkage. When gas pressure fills the bourdon tube, the tube begins to straighten out. As the tube straightens, it moves the linkage and the needle pointer.

Bourdon tubes are precision instruments that can be easily damaged. If the cylinder valve is opened quickly, and the regulator adjusting screw is not released, the tube can be cracked by the shock of a sudden increase in pressure. A sudden pressure increase can crack the tube, causing it to leak. A small leak in a bourdon tube can be repaired by silver brazing, but repairs of major damage to a regulator should be done by the manufacturer.

Torches. The primary causes of torch trouble are leaks in the mixing head seat, leaking needle valves, and clogged torch tubes. When the gas continues to flow after the valve is closed, you know the needle valve is leaking. This condition is caused by a worn or bent valve stem, a damaged valve seat, or loose packing around the needle valve. A leak in the mixing head seat allows the gases to escape and, unless you correct the trouble immediately, flashback is the dangerous result.

Cleaning a needle valve. Repair needle valve leaks around the seat by tightening the packing gland nut. If the leak is in the seat, remove the needle valve with a wrench and clean it. If it is worn or pitted, replace it with a new one. If the valve seat is scored, pitted, or otherwise damaged, the torch should be returned to the manufacturer for repair. Leaking mixing head seats should be removed and cleaned. If the seats are damaged, the torch should be returned to them manufacturer for repair.

Clean clogged torch tubes by removing the hoses and mixing head, and by blowing out each tube with 20 to 30 pounds of oxygen pressure.

Hose splice and clamps. Check the welding hose at regular intervals for leaks, worn spots, and loose connections. To find leaks in the hoses, immerse them in clean water while they are pressurized. Since worn or leaking hoses are dangerous and wasteful, they should be repaired or replaced immediately.

Repair leaks in the hose by removing the damaged section and inserting a hose splice.

NOTE:
Do not (by way of shortcut or for other reasons) put a piece of copper tubing in place of brass hose splice. Why? When copper and acetylene are placed together, they form copper acetylene, an unstable compound that will explode violently at the slightest shock. In short, do not use copper with acetylene.

Repair hoses leaking at the regulator or torch connection by cutting off 1 or 2 inches of hose and replacing the connections.

As you have learned, there are different ways of making copper connections. The first two methods of connections are known as the mechanical joints, now, we will look at soldering sweat and swage connections. Soldering these connections can be done by either soft soldering or silver soldering.

Soft-soldering copper joints. Soft soldering is a method of joining two metals together by allowing molten solder to run between the copper and fittings. The law of capillary attraction governs the force responsible for the bonding in solder joints. The copper must be cut to length, reamed, and cleaned before you are ready to solder the joints. Like welding, soldering uses a torch to perform this process. The most common equipment is the air-acetylene torch commonly known as the hydrocarbon torch.

Hydrocarbon Torch. The hydrocarbon torch is used for soft soldering by the direct flame method, or by using a flame-heated (indirect method) soldering iron. The hydrocarbon torch consists of a tank, tank valve, pressure regulator, hose, torch handle and tips. The tank contains the acetylene (fuel). When you open the tank valve, the acetylene is admitted to the regulator and to the tank pressure gauge. The regulator regulates the amount of pressure to the torch when you adjust the regulator knob. **(CAUTION: Do not use acetylene at pressure above 15 psi; to do so may cause an explosion) The tips may be changed to compensate for the various applications where more or less heat is required.**

Preparation. Your preparation of joints for soft soldering must be thorough. Metal surfaces must be perfectly clean at the joint to obtain a good bond between the base metal and the solder. You must remove all dirt, grease, oil, paint, etc., and make the metal bright. Clean the copper with a wire brush, file, emery cloth, or steel wool you may also use chemical cleaners.

Make sure that the parts to be joined fit together very closely. After the inside of the fitting and the outside end of the copper are cleaned, flux them to prevent oxidation. Put the fitting into position and prepare to heat the joint. A high-temperature concentrated flame, which will quickly bring the fitting to the melting point of solder, is the type of heat that is best for "sweating" fittings on copper. Fifty-fifty solder (50-percent lead and 50-percent tin) melts at 360° F. and free-flows at 415° F. Fifty-fifty solder is best for soft soldering on water lines. However, a solder with 95 percent tin and 5 percent antimony known as 95/5, is specially designed for refrigeration work.

Assembling the joint. When the fitting and copper are ready to be joined, apply heat evenly around the fitting. Do this by moving the flame back and forth. This procedure also keeps you from overheating the tube and fitting. Why is this important? Because, if the connection is overheated, the flux may burn out, causing oxidation, and the solder will not spread evenly.

Also, an overheated joint causes the solder to seep through the joint and flow away. Therefore you should occasionally test the heat by touching the fitting with solder where the copper and fitting join. Normally, thick wall-fittings require more heat than thin wall-fittings. When the tube and fitting melt the solder, the sweating may begin.

When the connection is hot enough to melt the solder, remove the flame and apply the solder to the edge of the fitting where it comes into contact with the tube. Solder, when confined between two surfaces, will run uphill by capillary attraction. Therefore, joints can be made in any position.

The amount of the solder required for a connection depends upon the diameter of the tube to be sweated. For instance, 1/4-inch of solder should be sufficient to solder a joint for l/4-inch tubing, 1/2-inch of solder for 1/2-inch tube.

When a line of solder shows up around the fitting—that is, when a bead of solder appears in the groove at the end of the fitting—the joint has all the solder it will take. When you apply solder to a tee, feed solder from both ends of the fitting. Reheat the fitting slightly to help the solder penetrate into the metal. Remove the flame and continue to feed the solder to make sure the joint is filled.

Allow the joint to cool for a short while. A rag saturated with water will hasten this cooling. When you cool male and female adapters, allow more time for the solder to set. Because these fittings are heavier, they hold heat longer, and they do not cool as quickly.

When unsoldering copper from a fitting on which other soldered connections are to be left intact, make sure that you do not melt the solder in the other connections. Keep the connections that are to be left intact cool by applying damp cloths to them. You may also use damp cloths to protect valves and other units from the intense heat. Make a shield from a piece of metal and slip it over the tubing to protect combustible materials or a flammable wall while you are soldering.

Silver-soldering copper joints. In silver-soldering, you produce the bond by heating the base metal to a temperature between 1175° F. and 1600° F. and adding a silver alloy filler metal with a melting point within this temperature range. Silver-soldering (also known as silver brazing); uses a silver brazing alloy made up of a combination of copper (Cu), phosphorous (p), and nickel (Ni).

Joints that permit capillary attraction are best suited for silver soldering because of the high strength obtained. Since the silver alloy filler metal flows at a low temperature, less heat is required, thus offering a number of definite advantages. Because of the low temperature required, you do not heat the metal to temperatures at which its physical properties or other qualities are impaired. Distortion is held to a minimum. The process is quite simple, and you can complete it rapidly. Silver alloy filler metals join virtually all ferrous and nonferrous metals with the exception of aluminum, magnesium, and several other alloys and metals with a low melting point. The strength of a silver-soldered joint depends upon the fit and the quality of the bond between the filler metal and the base metal. Heat opens the crystal grain structure and lets the filler metal penetrate along the grain boundaries on the surface of the base metal. This creates a physical bond that produces the high strength of a solder joint. No fusion takes place between the filler metal and the base metal. Do not subject parts that are silver soldered to temperatures that exceed 500° F. The silver-soldered bond weakens at that temperature and becomes progressively weaker as the temperature increases.

Silver-solder comes in several grades, with a silver content ranging from 10 to 80 percent and with a melting point from 1140°/1160° F. It comes in rod, strip, wire, and granulated form. Use the strip or ribbon form for fixed setups in which you place the solder in the joint before you apply heat. use the rod and wire forms when it is preferable to apply the solder by hand.

There are several factors to consider when planning a silver-soldered joint, including:

- Joint design.
- Joint preparation.
- Fluxing.
- Tip size.
- Technique.

Joint design. The type of joint you use depends mainly on the base metal and the service requirements of the joint. The type of joint is important because the preparation, fit, and results obtained with silver soldering differ from fusion welding. You should not use silver alloy as filler. This alloy flows freely into narrow openings, and the strongest joints result from using very small clearances between the joint surfaces. The recommended joint clearance at soldering temperature is between 0.002 and 0.005 inch.

The most common type of joint that you will silver solder is the swaged joint. This type of joint is used to join the copper tubing, both soft drawn and annealed, that is used in HVAC systems. It is used to join copper tubing for air conditioning and heating systems.

Joint preparation. You need a clean, oxide-free surface to ensure uniform quality and a soundly soldered joint. Remove all grease, oil, dirt, and oxides from the base metal and the filler rod to obtain uniform capillary attraction throughout the joint. Complete the soldering as soon as possible after cleaning the base metal and filler metal. Use either mechanical or chemical cleaning. For rust and heavy oxides, use sandblasting. For grease and oil, use a suitable solvent. Other cleaning agents and machines are the grinder, buffer, emery cloth, vapor degreaser, file, and certain acids. When you use chemical cleaners, wash the metal to remove any residue because residues can attack the base metal or form an undesirable film on the surface. In repairing broken tools and parts, you must thoroughly remove paint, lacquer, or other coatings from the surface before you try to solder the break. Also, remove plating, such as chrome or cadmium. The solder must make contact with the clean surface of the original metal.

Flux. Flux serves various purposes in making strong, uniform soldered joints. A good flux performs the following functions:

- React chemically with surface films, such as oxides, reducing them and cleaning the metal surfaces to receive the molten silver alloy.

- Forms a protective film during the soldering cycle, preventing re-oxidation at the elevated temperatures required of soldering.

- Assists the silver alloys to flow freely. Using flux does not eliminate the need for cleaning the parts before silver soldering. The flux supplements the initial cleaning by dissolving, restraining, and otherwise rendering ineffective any products of the soldering operation that could impair the quality of the joint or prevent bonding.

Flux comes in a variety of forms, such as powder, paste, liquid, and solid. Remove the flux after you complete the soldering. Trapped flux can weaken or corrode the soldered joint. You can usually clean the flux off by washing the parts in hot water. If the joint can take a moderate heat shock, you can remove the flux easily by immersing the joint in water while the joint is still warm. Several good ready-mixed fluxes are available commercially, but you can substitute the following mixtures: a mixture of equal parts of borax and boric acid for copper, brass, bronze, and Monel metal; and a mixture of 3 parts boric acid and 1 part borax for steel. Apply the flux in powder form, or dissolve it in water and apply it with a brush. The temperature that the flux begins to flow freely is the proper temperature for applying the solder.

Tip sizes. The tip size depends basically upon the thickness of the base metal. However, because of the melting point of the silver solder you are using and the joint design, you may use a slightly larger or smaller tip.

Technique. For silver soldering, adjust the torch to a neutral or slightly carburizing flame. Do not let the inner core of the carburizing flame touch the metal, since this can cause the filler metal to be sluggish at the flow point and the flux to burn. Keep the torch in motion all the time it is in use. Holding it in one place too long can easily overheat the base metal and the flux. If a part overheats and the capillary flow of the solder is hindered, re-clean the part and remove all oxides and foreign matter. Low heat and cleanliness are very important in silver soldering.

For large surfaces or thick metals, preheat the metal well away from the joint, especially if you are soldering metals with high heat conductivity. Be careful in soldering metals of unequal thickness or unequal heat conductivity because all metal parts should reach the soldering temperature at the same time. The forming of a small fillet at the face of the joint indicates complete bonding through the joint.

Review Questions
for
Braze and Solder

Question	Answer
1. Oxygen is a colorless, tasteless, and odorless gas that is slightly heavier than air.	a. True b. False
2. The oxygen cylinder is made of seamless _____ and contains oxygen at a pressure of up to 2,000 pounds per square inch (psi).	a. steel b. zinc c. copper d. aluminum
3. When a cylinder is empty, replace the safety cap and write "___" on the cylinder in chalk.	a. MT b. MIT c. NIT d. EMPTY
4. The oxygen cylinder is green and equipped with a safety cap to protect the _____.	a. valve b. inlet valve c. nozzles d. flare valve
5. Acetylene cylinders are equipped with a cylinder valve and a protective cap. As a safety factor, the valve has _____ threads to prevent an improper connection.	a. left-hand b. right-hand c. copper d. cross
6. Both oxygen and acetylene cylinders should be stored according to _____ regulations.	a. Air Force b. DOD c. ITRO d. OSHA
7. When storing acetylene cylinders, it is not necessary to separate full and empty cylinders.	a. True b. False
8. The regulators are mechanical devices that _____ the high pressure of the gases as they flow from the cylinders.	a. reduce b. moderate c. increases d. terminate
9. The oxygen hose is always green or black, and the acetylene hose is always red or maroon.	a. True b. False
10. _____ helps to prevent a flashback from burning back into the oxygen or acetylene hoses.	a. Flashback arrestors b. Regulators c. Torch wrenches d. Flashback regulators
11. When disassembling an oxyacetylene outfit, it is not necessary to disconnect the hoses from the torch.	a. True b. False

Review Questions
for
Braze and Solder

Question	Answer
12. You can clean clogged torch tubes by removing the hoses and mixing head, and by blowing out each tube with _____ of oxygen pressure.	a. 20 to 30 pounds b. 2 to 3 pounds c. 25 to 35 pounds d. .20 to .30 pounds
13. Soft soldering is a method of joining two metals together by allowing molten solder to run between the _____ and fittings.	a. copper b. aluminum c. zinc d. iron
14. The _____ torch is used for soft soldering by the direct flame method, or by using a flame-heated (indirect method) soldering iron.	a. hydrocarbon b. fluorocarbon c. oxycarbon d. acetycarbon
15. Solder, when confined between two surfaces, will run uphill by _____ attraction.	a. capillary b. ancillary c. osmotic d. auxiliary
16. When cleaning a needle valve, you can repair leaks around the seat by tightening the packing gland nut.	a. True b. False

BRAZE AND SOLDER

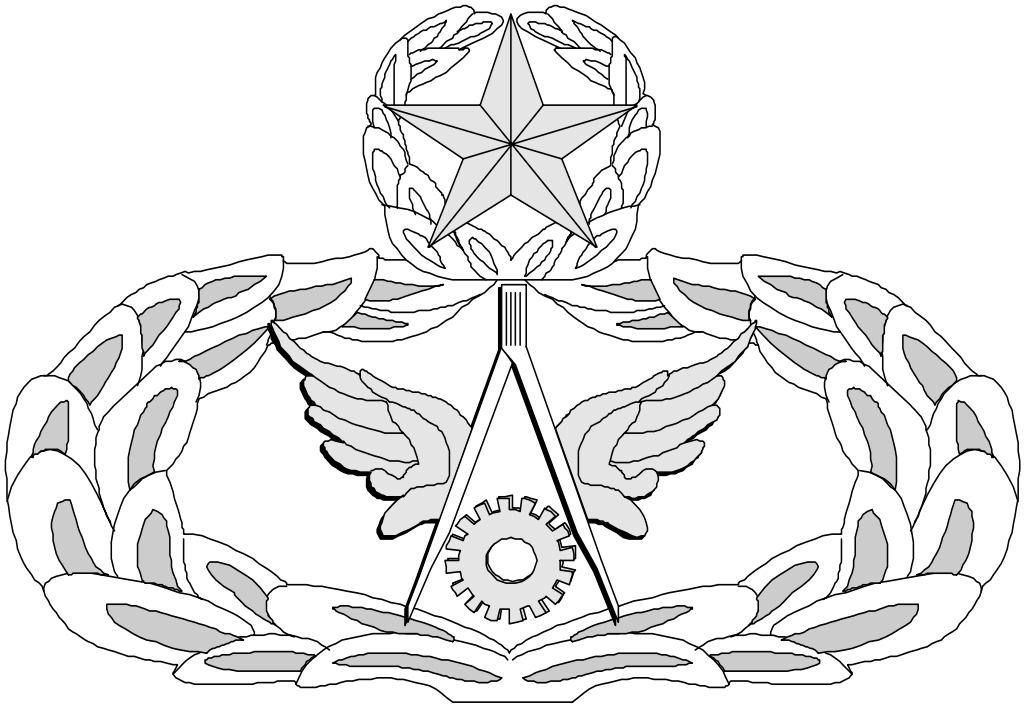
Performance Checklist		
Step	**Yes**	**No**
Operational Test		
1. Demonstrate Assembly and use of the Oxyacetylene Equipment		
a. Explain Safety Procedures		
b. Attach the Two Stage Regulators to their Respective Cylinders		
c. Attach Hoses to Proper Regulators		
d. Attach Torch to Proper Hoses		
e. Attach Torch Tip to the Torch		
f. Adjust Regulators to Proper Pressures		
g. Light the Torch		
2. Demonstrate Soldering a ½" Elbow on a ½" Copper Tubing		
a. Explain Safety Procedures		
b. Lighting the Torch		
c. Soldering the Elbow on the Tubing		
3. Explain Emergency shutdown procedures		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

Air Force Civil Engineer

QUALIFICATION TRAINING PACKAGE (QTP)

REVIEW ANSWER KEY



For

HVAC/REFRIGERATION

(3E1X1)

MODULE 13

WELDING & CUTTING

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

BRAZE AND SOLDER

(3E1X1-13.2.2.)

Question	Answer
1. Oxygen is a colorless, tasteless, and odorless gas that is slightly heavier than air.	a. True
2. The oxygen cylinder is made of seamless _____ and contains oxygen at a pressure of up to 2,000 pounds per square inch (psi).	a. steel
3. When a cylinder is empty, replace the safety cap and write "___" on the cylinder in chalk.	a. MT
4. The oxygen cylinder is green and equipped with a safety cap to protect the _____.	a. valve
5. Acetylene cylinders are equipped with a cylinder valve and a protective cap. As a safety factor, the valve has _____-hand threads to prevent an improper connection.	a. Left-Hand
6. Both oxygen and acetylene cylinders should be stored according to _____ regulations.	a. Air Force
7. When storing acetylene cylinders, it is not necessary to separate full and empty cylinders.	b. False
8. The regulators are mechanical devices that _____ the high pressure of the gases as they flow from the cylinders.	a. reduce
9. The oxygen hose is always green or black, and the acetylene hose is always red or maroon.	a. True
10. _____ help to prevent a flashback from burning back into the oxygen or acetylene hoses.	a. Flashback arrestors
11. When disassembling an oxyacetylene outfit, it is not necessary to disconnect the hoses from the torch.	b. False

BRAZE AND SOLDER

(3E1X1-13.2.2.)

Question	Answer
12. You can clean clogged torch tubes by removing the hoses and mixing head, and by blowing out each tube with _____ of oxygen pressure.	a. 20 to 30 pounds
13. Soft soldering is a method of joining two metals together by allowing molten solder to run between the _____ and fittings.	a. copper
14. The _____ torch is used for soft soldering by the direct flame method, or by using a flame-heated (indirect method) soldering iron.	a. hydrocarbon
15. Solder, when confined between two surfaces, will run uphill by _____ attraction.	a. capillary
16. When cleaning a needle valve, you can repair leaks around the seat by tightening the packing gland nut.	a. True